MAV State-of-the-Art & Technology Drivers

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Report Documentation Page

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Overview

- **Introduction**
- **Todays MAV, State-of-the-Art**
- **Technology Drivers**
- **Summary & Outlook**

Today‘s UAV

Unmanned, Unattended or Unassisted

Air Vehicles

Overview

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Classification of MAV

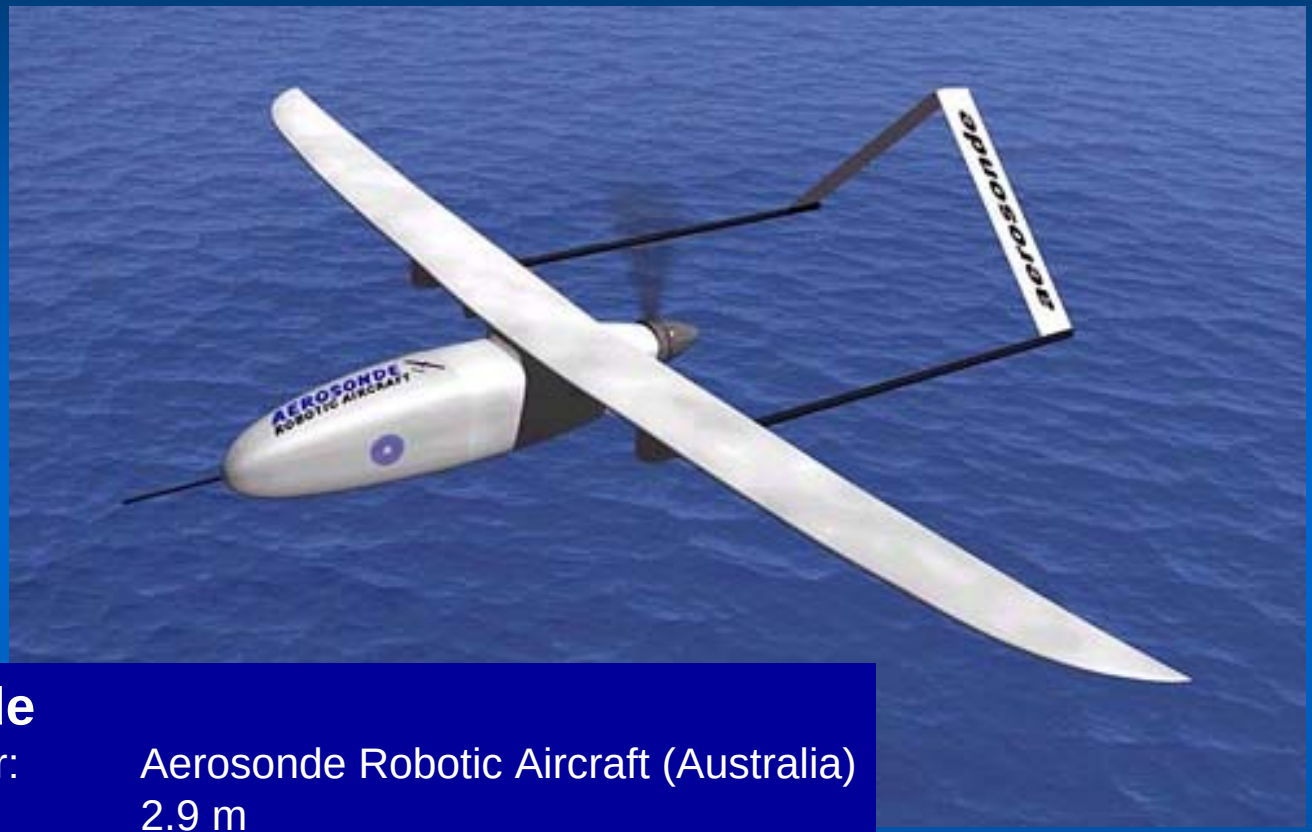
Development Status:

1. **operational**
   - In use in higher quantities
   - commercial or military use
2. **prototype**
   - functional aircraft
   - technology demonstrator
3. **Under development**
   - not fully functional

Grade of Autonomy:

1. **manually controlled**
   - completely remote-controlled
2. **semi-autonomous**
   - aircraft keeps altitude and track
   - operator commands up-down / left-right
3. **fully autonomous**
   - aircraft follows waypoints
   - no intervention of operator necessary

Today‘s MAV



Aerosonde

Manufacturer:	Aerosonde Robotic Aircraft (Australia)
Wingspan:	2.9 m
Mass:	14 kg
Payload:	max. 5 kg (fuel tradeoff)
Endurance:	> 50 hrs
Status:	operational (fully autonomous)

Today‘s MAV

MLB Bat

Manufacturer:	MLB (USA)
Wingspan:	152 cm
Mass:	4.5 kg
Payload:	0.5 kg
Endurance:	1 hr
Status:	operational (fully autonomous)

Today‘s MAV

Aladin

Manufacturer:	EMT (Germany)
Wingspan:	150 cm
Mass:	3 kg
Payload:	300 g
Endurance:	30 min.
Status:	operational (fully autonomous)

Today‘s MAV

Carolo XL

Manufacturer:	Aerospace Systems, TU Braunschweig (Germany)
Wingspan:	100 cm
Mass:	940 g
Payload:	30 g
Endurance:	30 min.
Status:	prototype (fully autonomous)

Today‘s MAV

Mikado

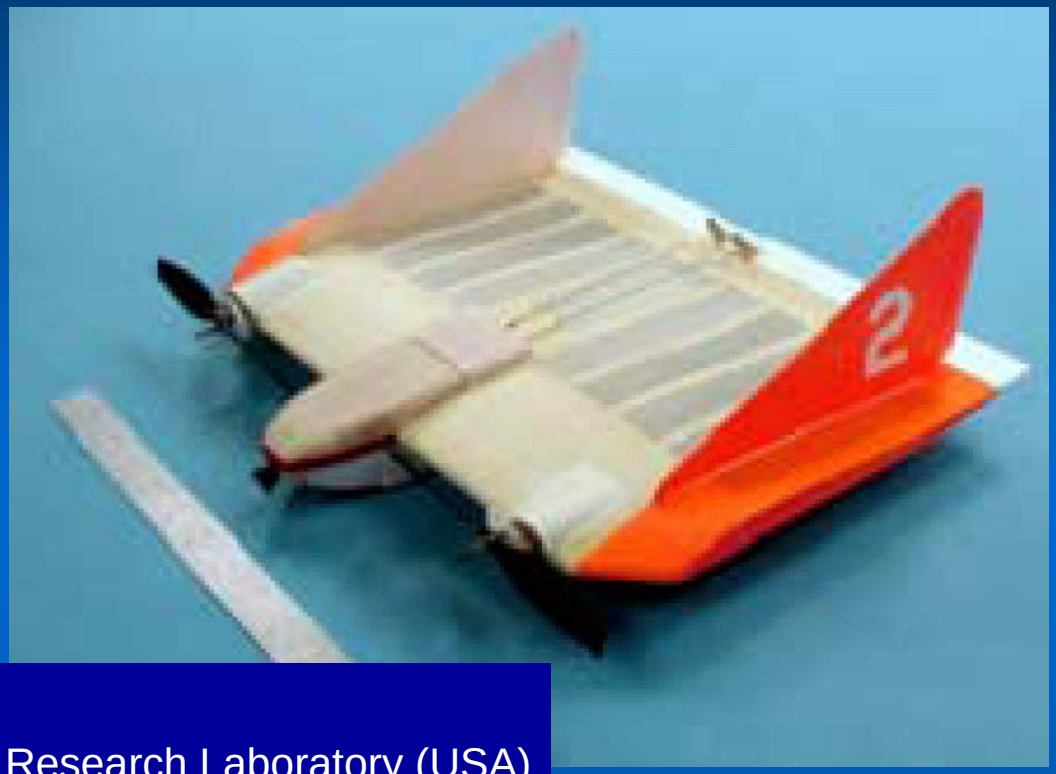
Manufacturer:	EMT (Germany)
Wingspan:	?
Mass:	?
Payload:	?
Enduracce:	?
Status:	under development

Today‘s MAV

Carolo

Manufacturer:	Aerospace Systems, TU Braunschweig (Germany)
Wingspan:	40 cm
Mass:	380 g
Payload:	20 g
Endurance:	30 min.
Status:	under development (fully autonomous)

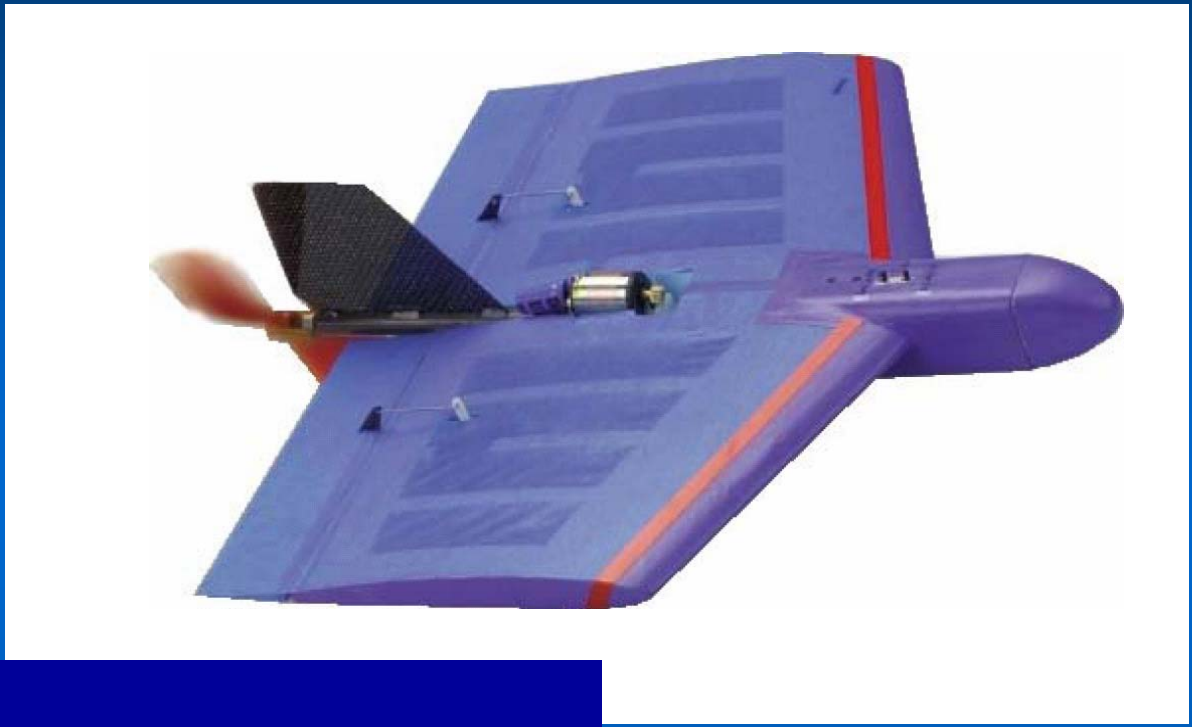
Today‘s MAV



MITE 2

Manufacturer:	Naval Research Laboratory (USA)
Wingspan:	37 cm
Mass:	130 g to 210 g
Payload:	camera
Endurance:	max. 30 min.
Status:	prototype (manually controlled ?)

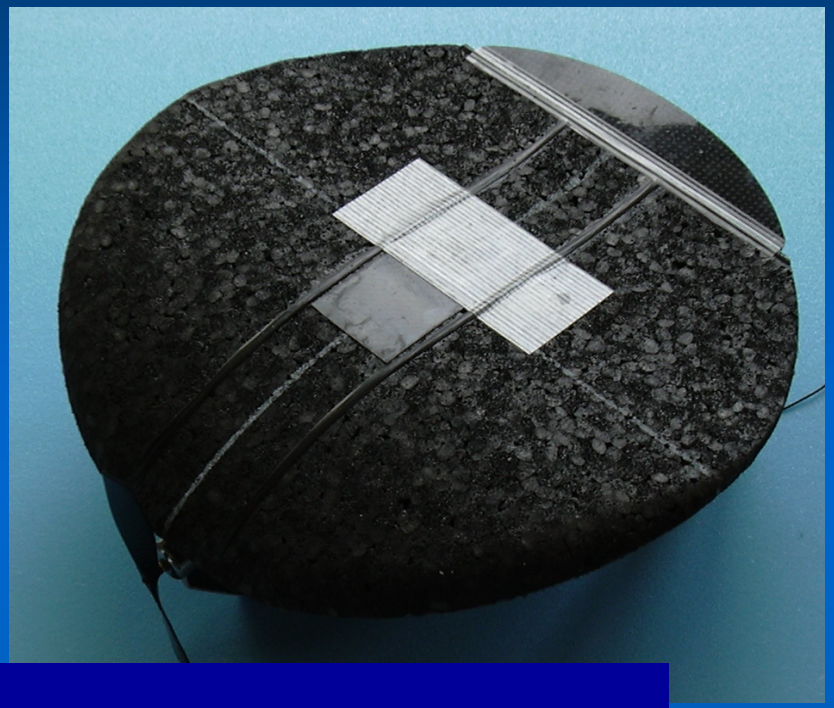
Today‘s MAV



Dornier MAV

Manufacturer:	EADS Dornier (Germany)
Wingspan:	30 cm
Mass:	200 g
Payload:	b/w camera
Endurance:	15 min.
Status:	prototype (semi-autonomous)

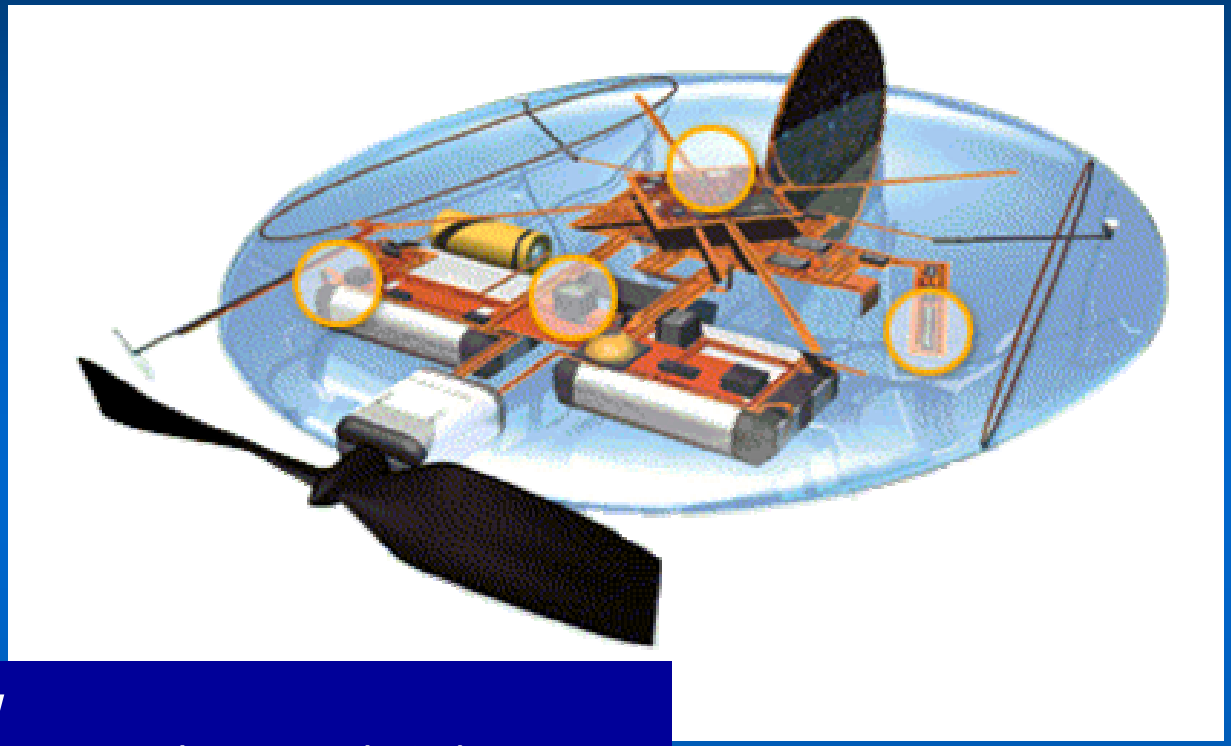
Today‘s MAV



RWTH Aachen MAV

Manufacturer:	Chair of Flight Dynamics, RWTH Aachen (Germany)
Wingspan:	20 cm
Mass:	90 g
Payload:	camera
Endurance:	18 min.
Status:	prototype (manually controlled)

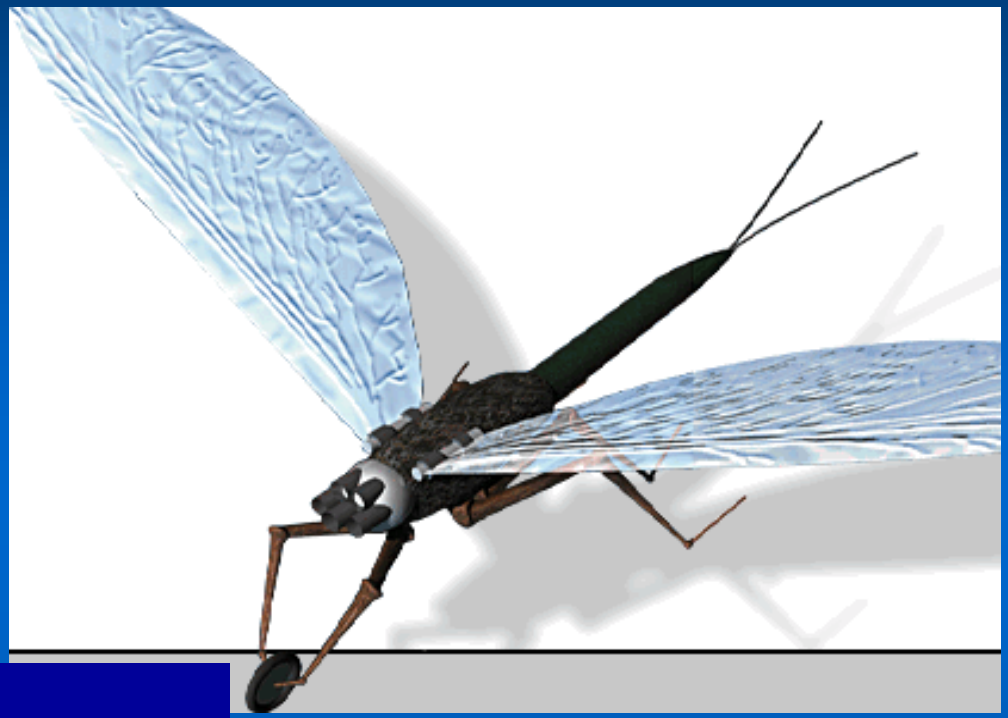
Today‘s MAV



Black Widow

Manufacturer:	AeroVironment (USA)
Wingspan:	15 cm
Mass:	42 g
Payload:	5 g
Endurance:	30 min.
Status:	prototype (semi-autonomous ?)

Tomorrow‘s MAV



Entomopter

Manufacturer:	GeorgiaTech (USA)
Wingspan:	?
Mass:	?
Payload:	?
Endurance:	?
Status:	under development

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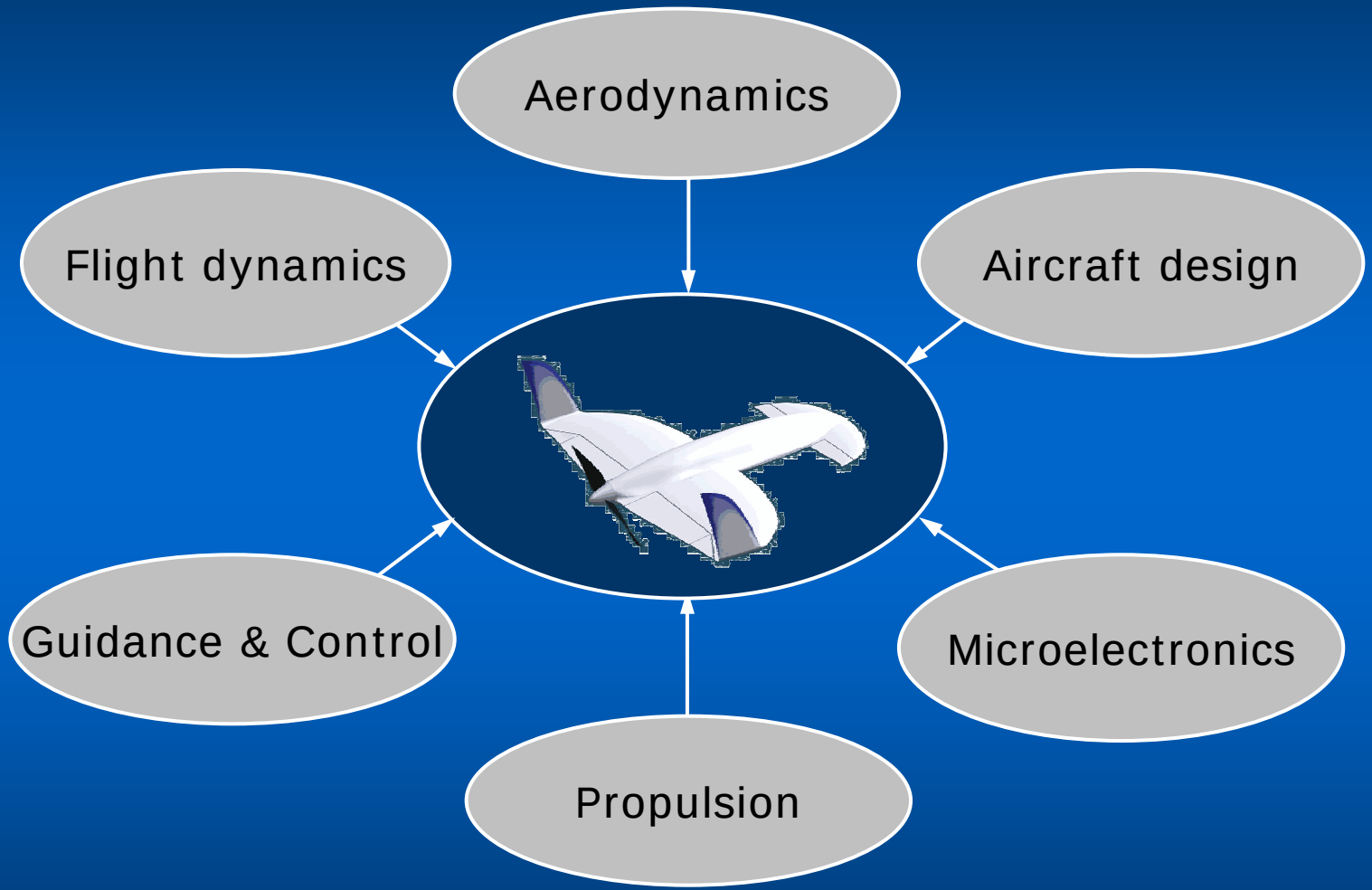
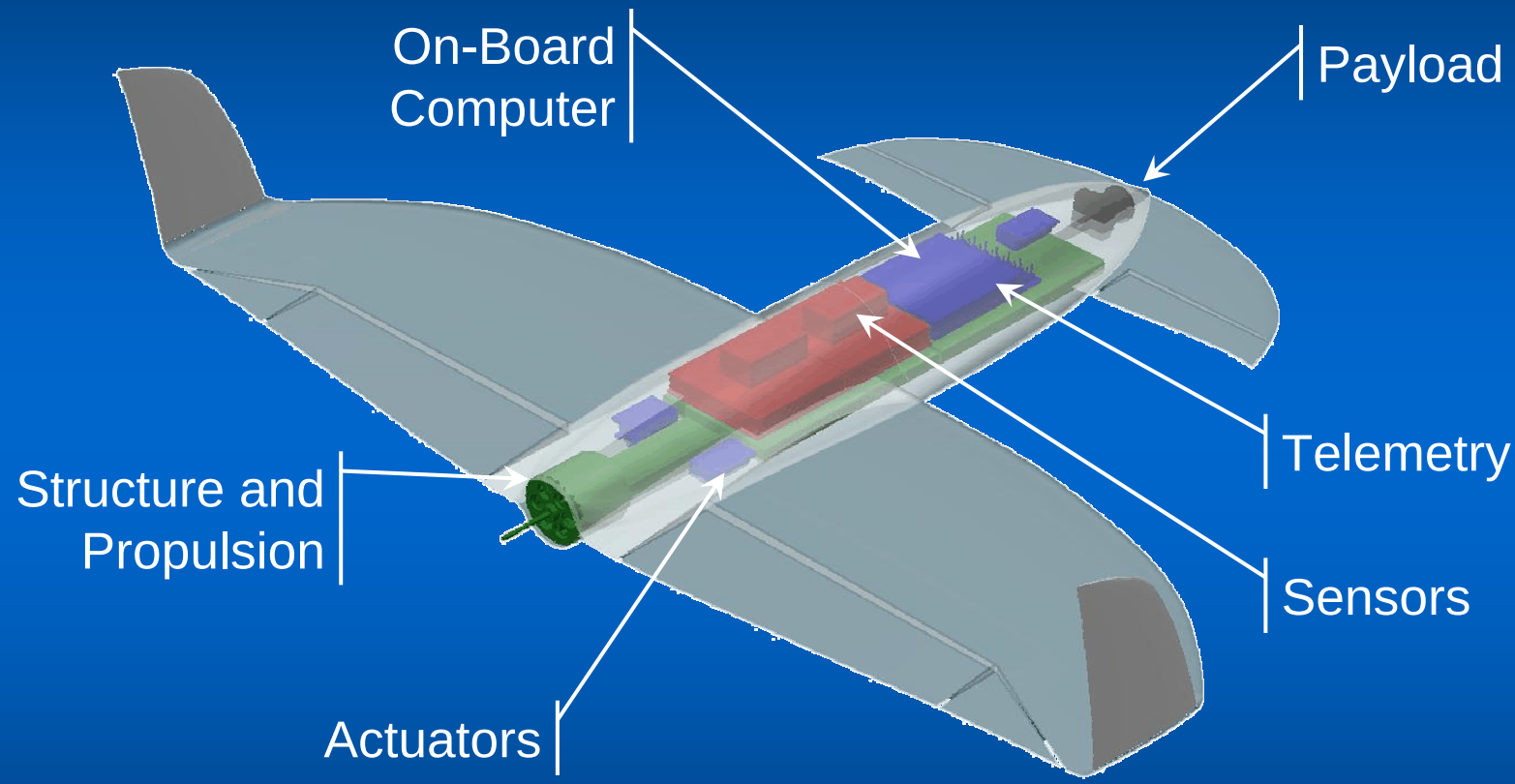
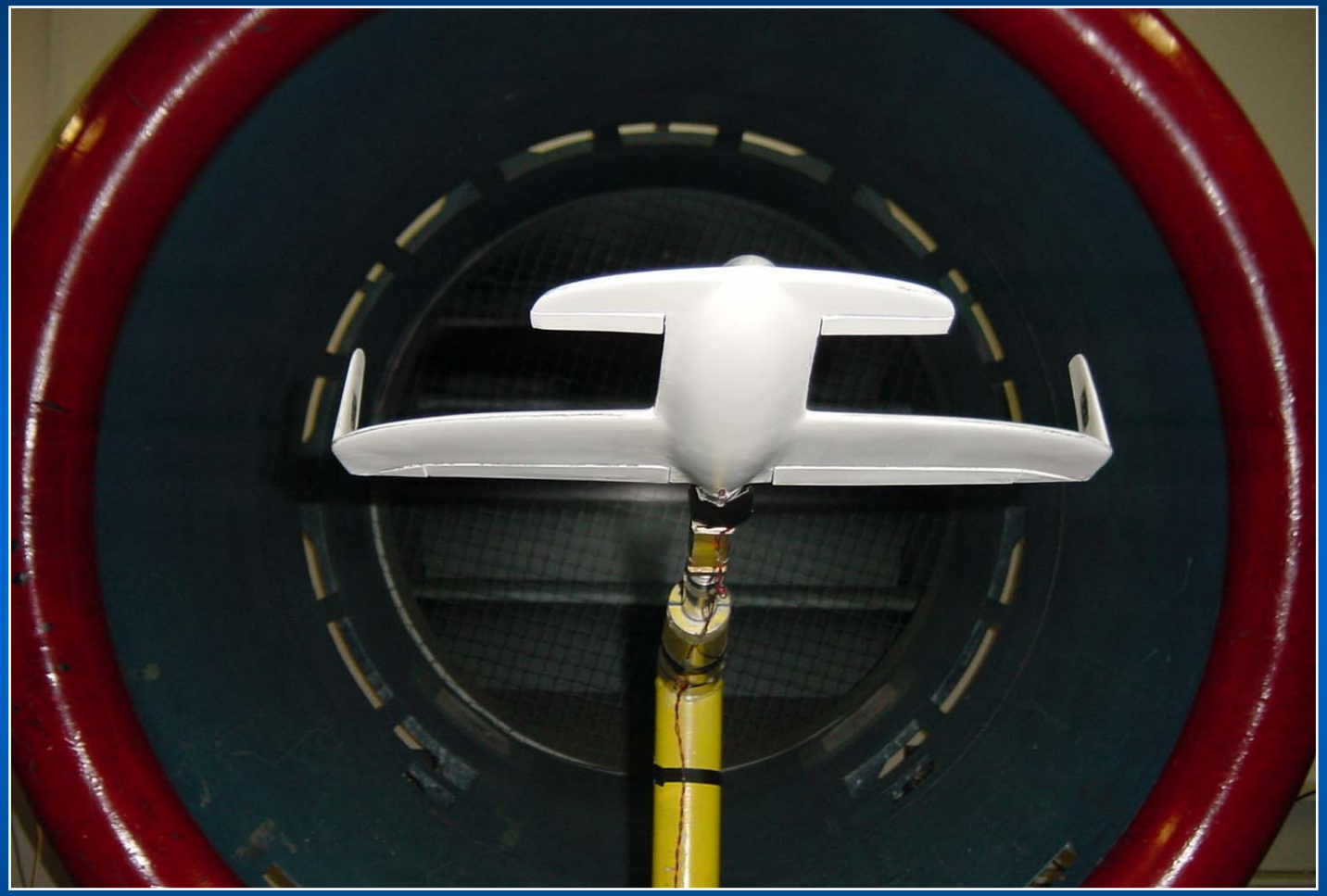
A Multidisciplinary Research Activity



Transparent view of Carolo

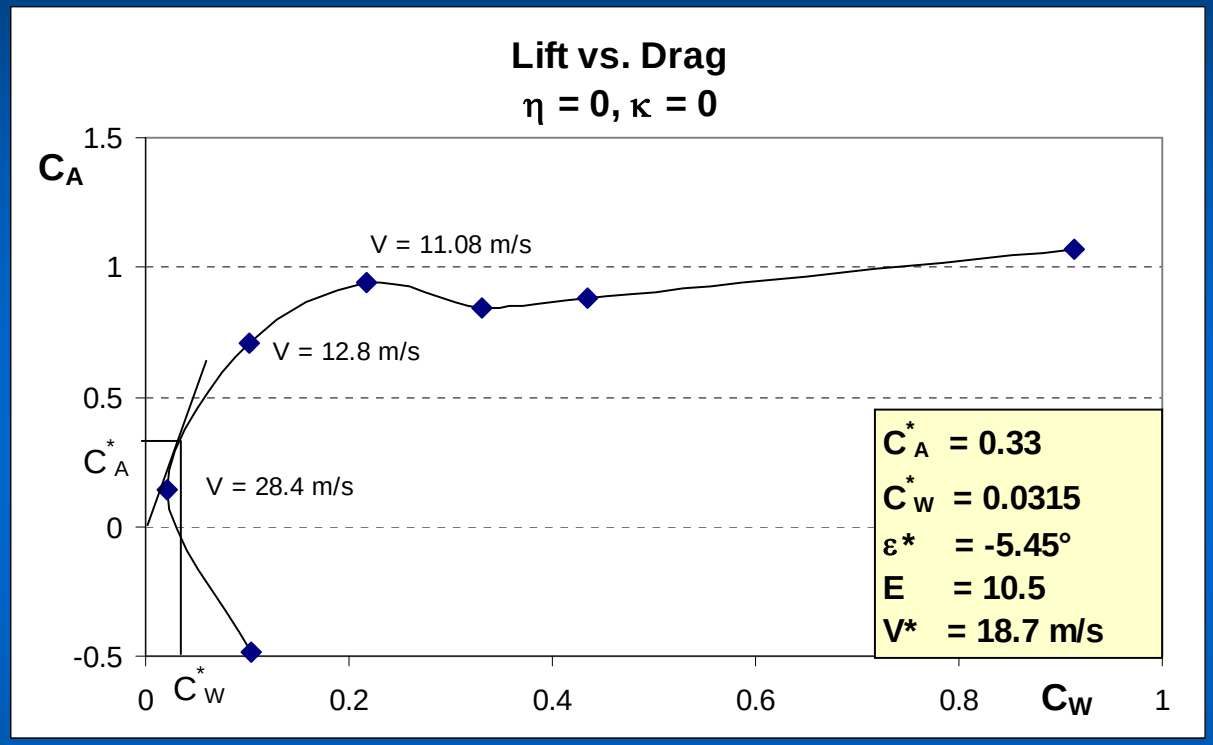


Aerodynamics – Low Re-Numbers



CAROLO during wind tunnel tests at the Institute of Fluid Dynamics, Technical University of Braunschweig

Results - Aerodynamics

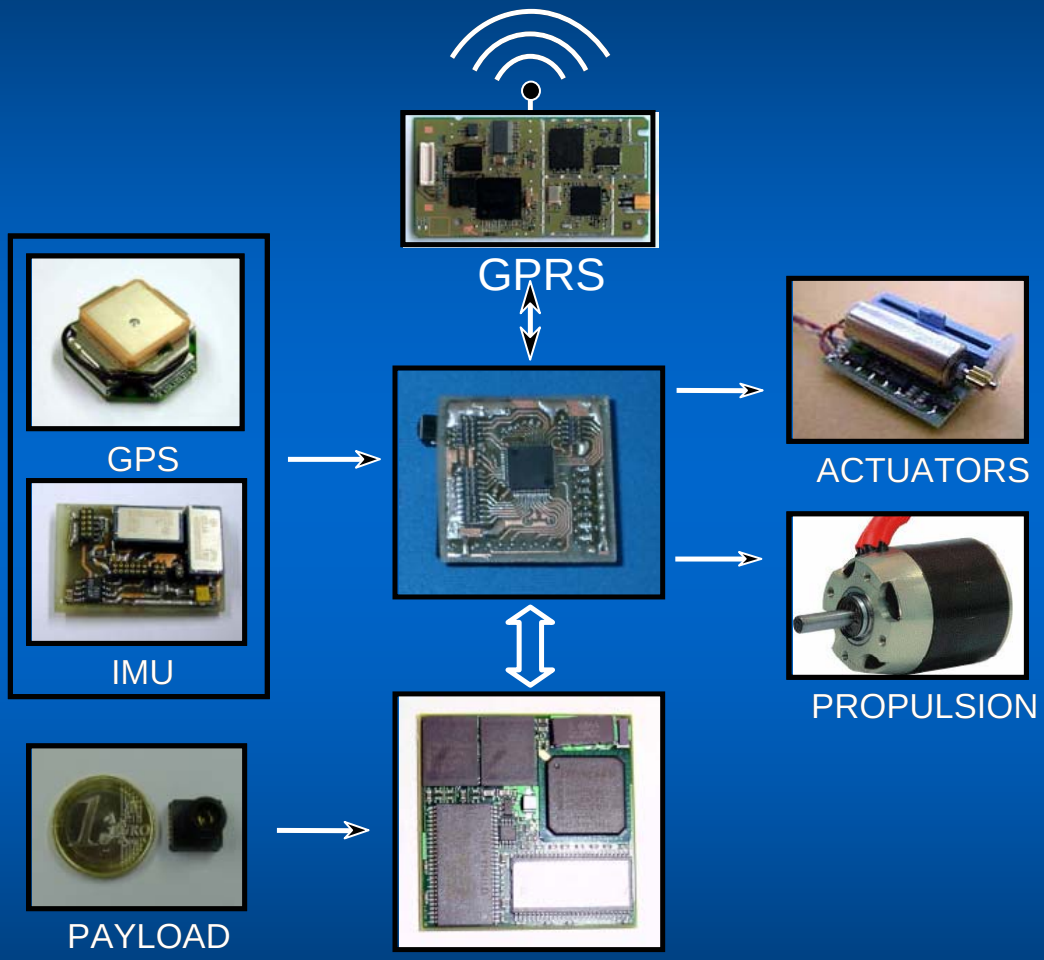


min. glide angle	-5,45°
optimal speed	18.7 m/s

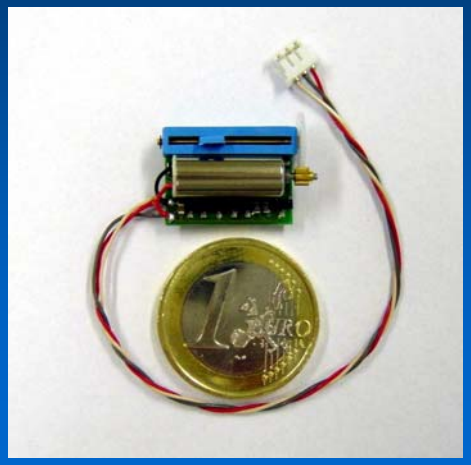
uncritical stall behavior

flow separation at α_S = 15°

Microelectronics

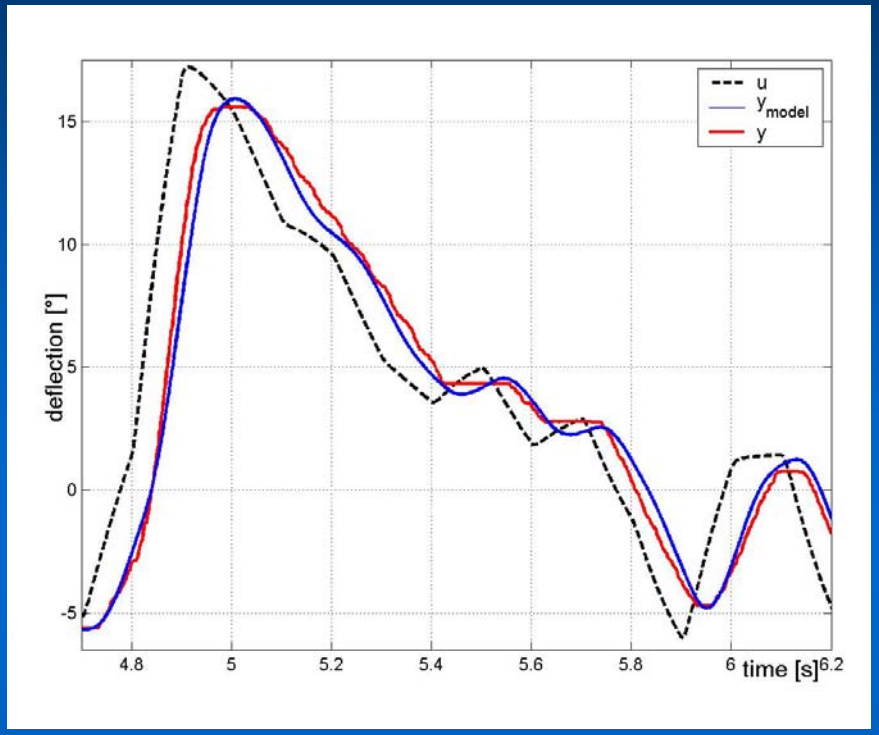


Theoretical work – actuator dynamic‘s



WES-Technik Light Servo 3.0

mass:	3 gram
velocity:	95 mm/s
servo force:	2 N

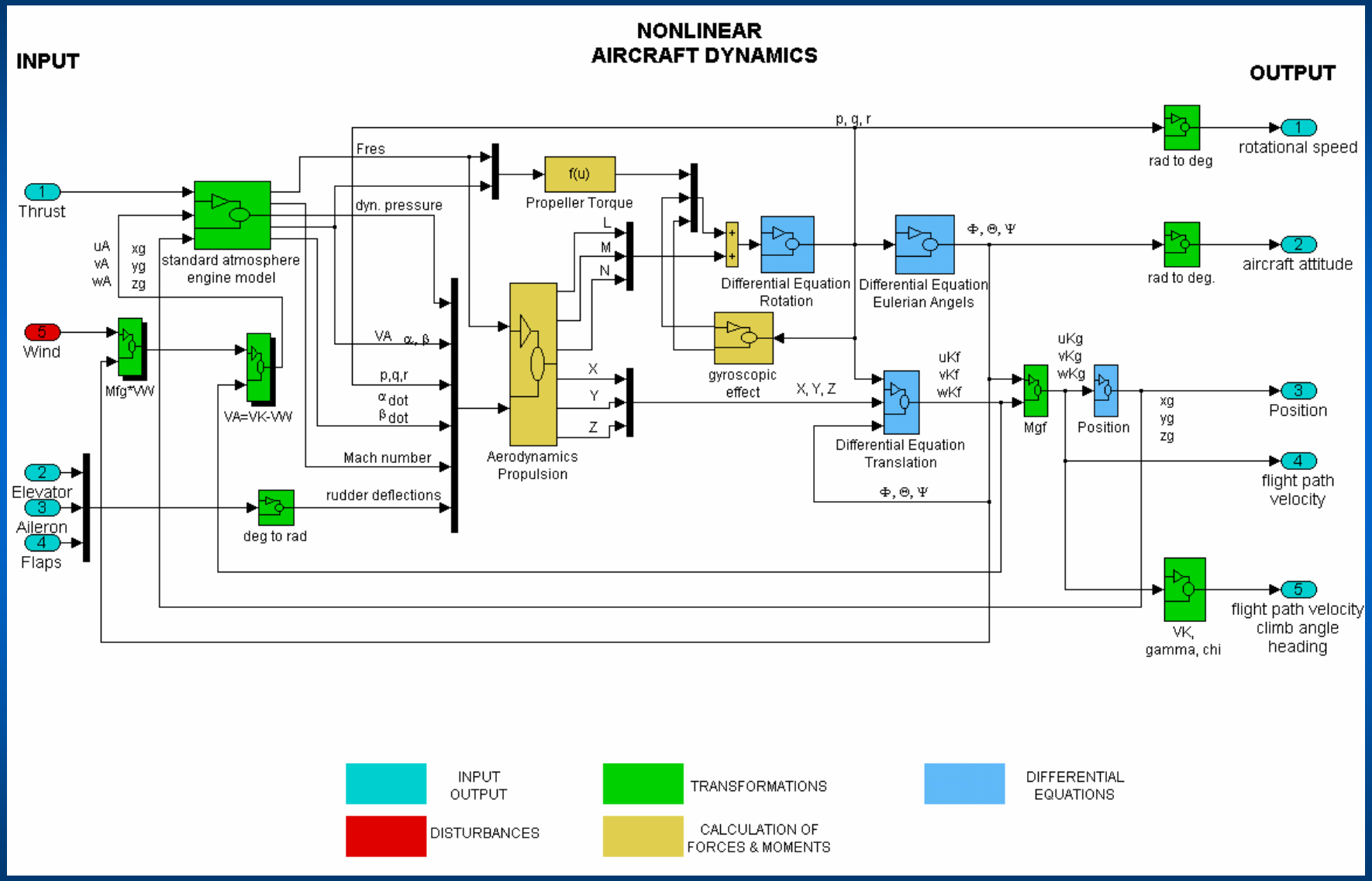


$$y_S(s) = \frac{K}{Ts+1} \cdot e^{-j\omega T_t} \cdot u(s)$$

T = 0.0165 s

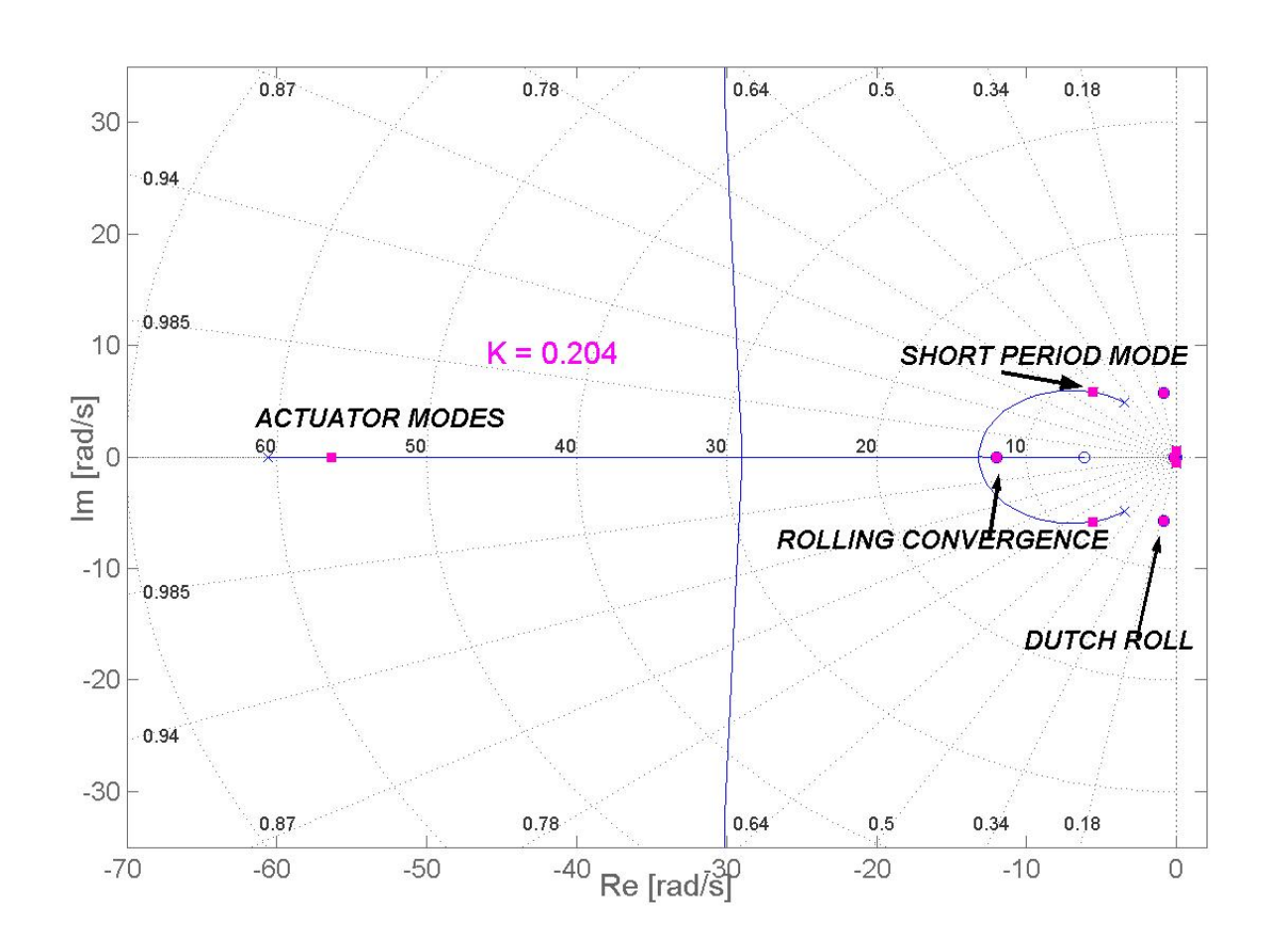
T_t = 0.008 s

Flight Dynamics



Results – Stability Analysis

Root Locus
with Actuator Dynamics

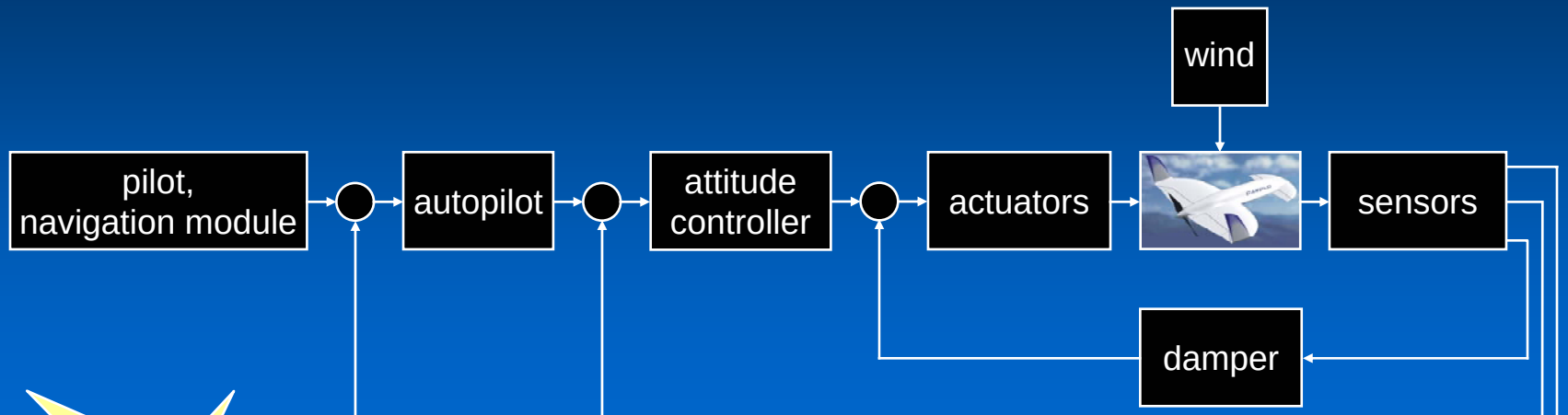


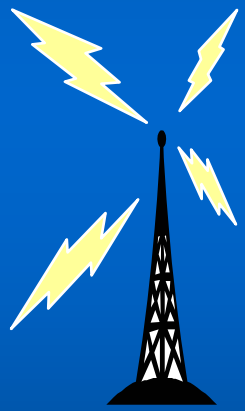
K: Pitch damping controler gain

-all open loop modes are stable

-with increasing feedback gain one real pair of the SPM combines with the actuator mode to a new oscillatory motion

Guidance & Control





telemetry

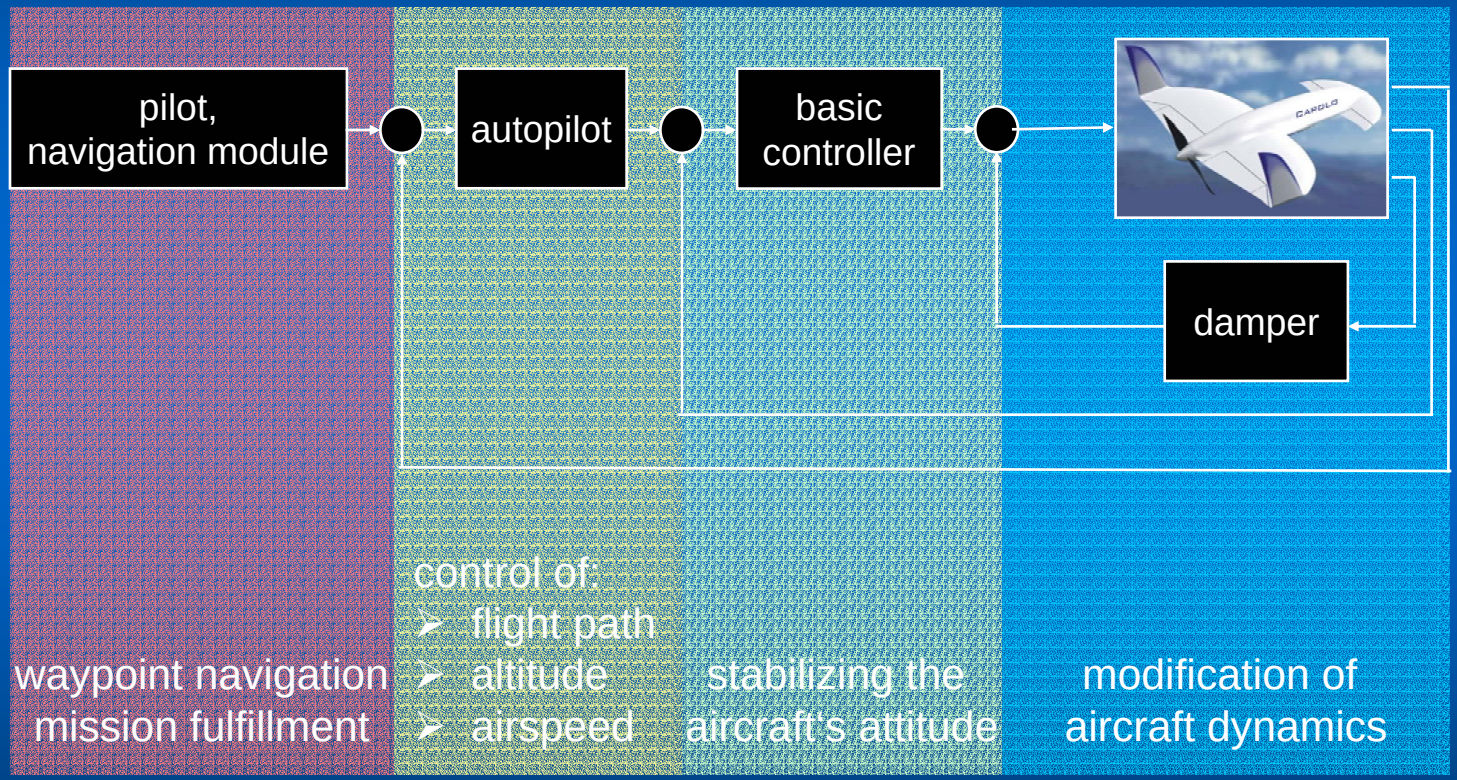
ground control

Development of:

- onboard electronics
- telemetry
- ground control software

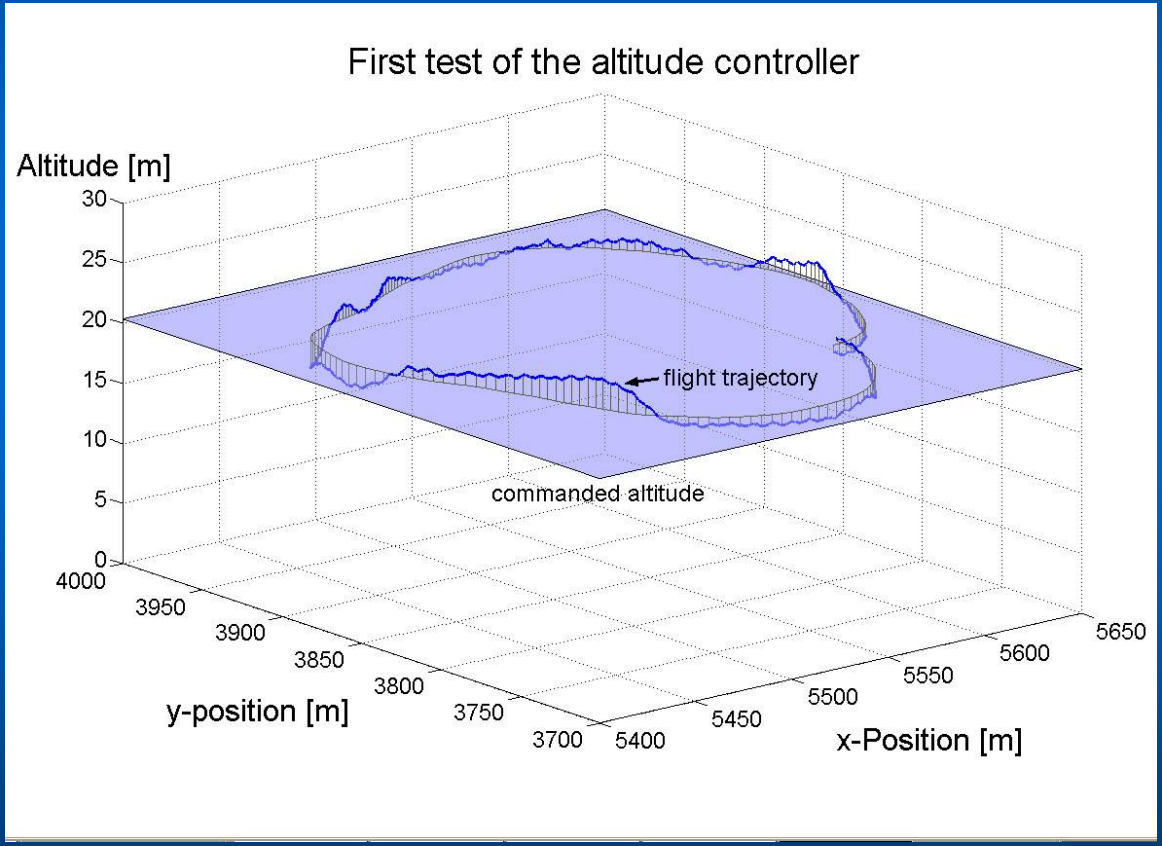
Theoretical work – flight controller

cascaded flight controller concept



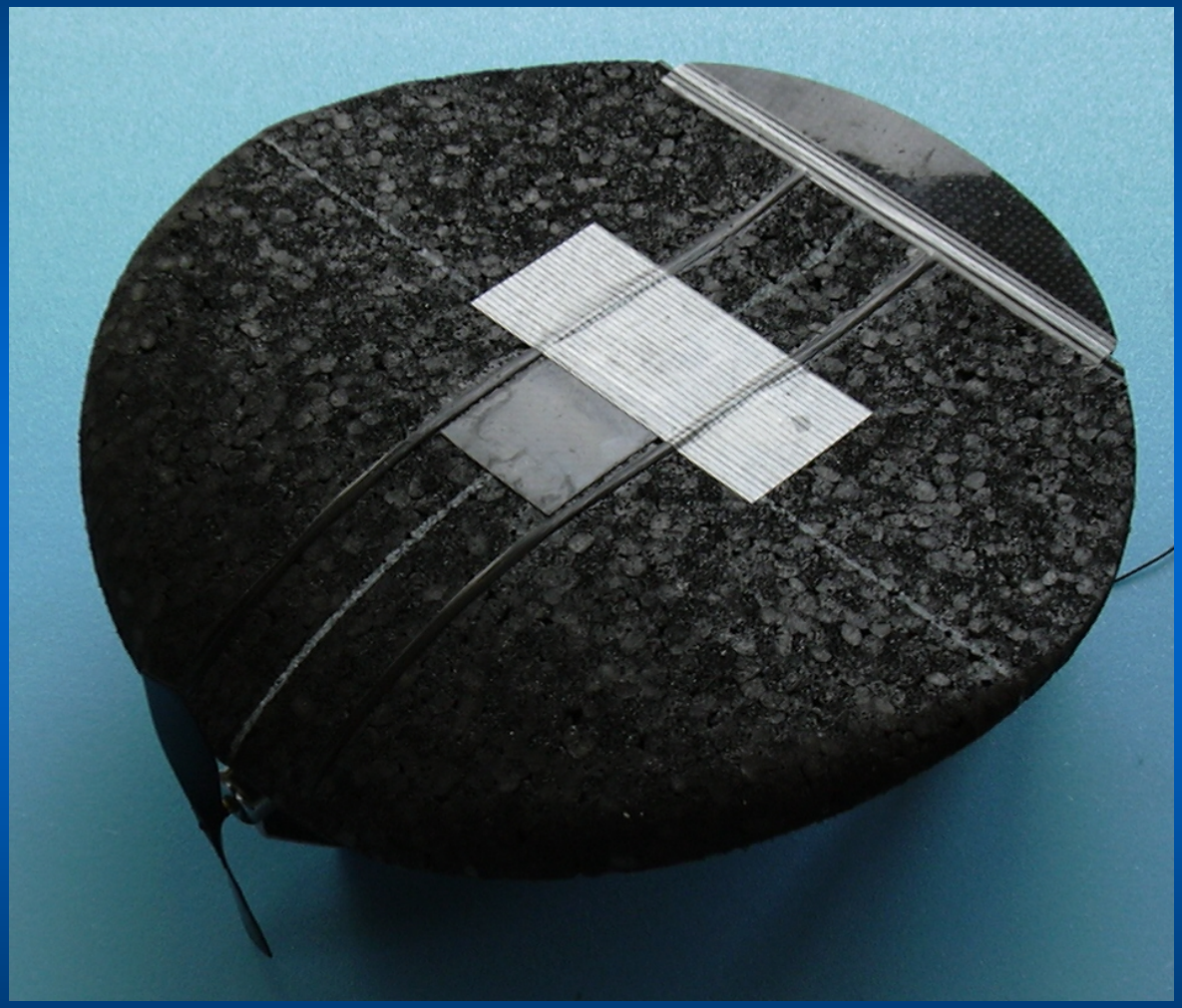
Altitude Controller

August 2003



- no optimized feedback gains
- circling during strong thermal activity
- $\Delta H < 2m$

Propulsion



RWTH Aachen MAV

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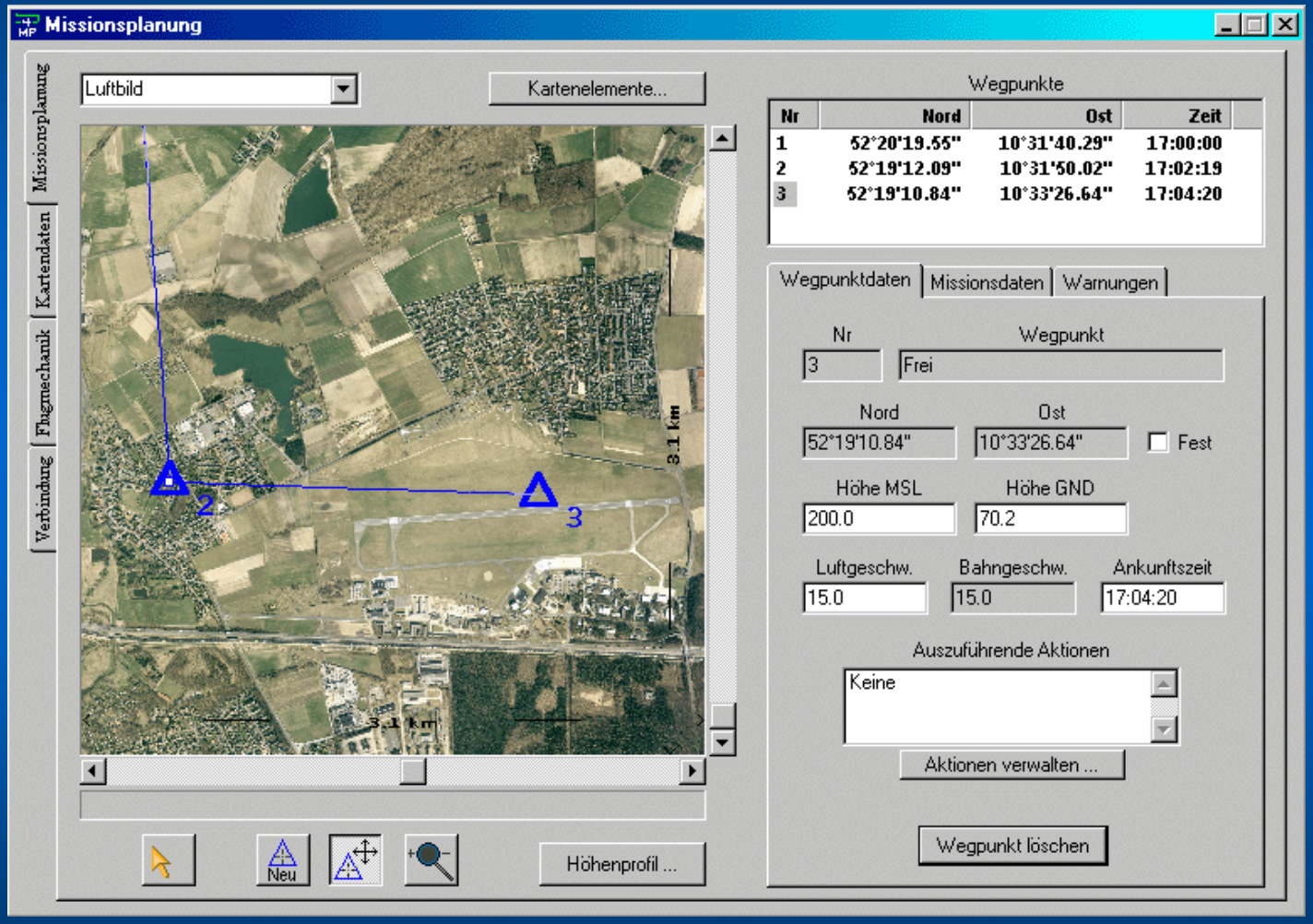
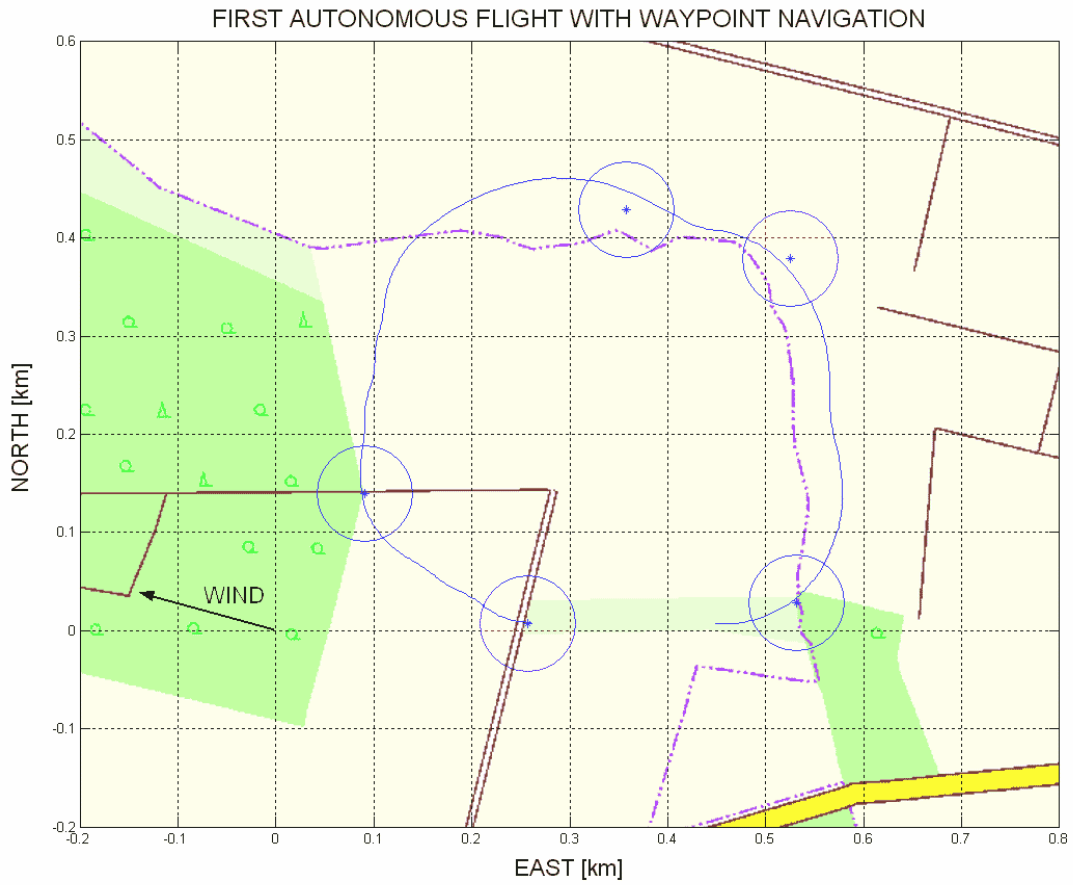
Ground Control Software



Autonomous Flight – Waypoint Navigation

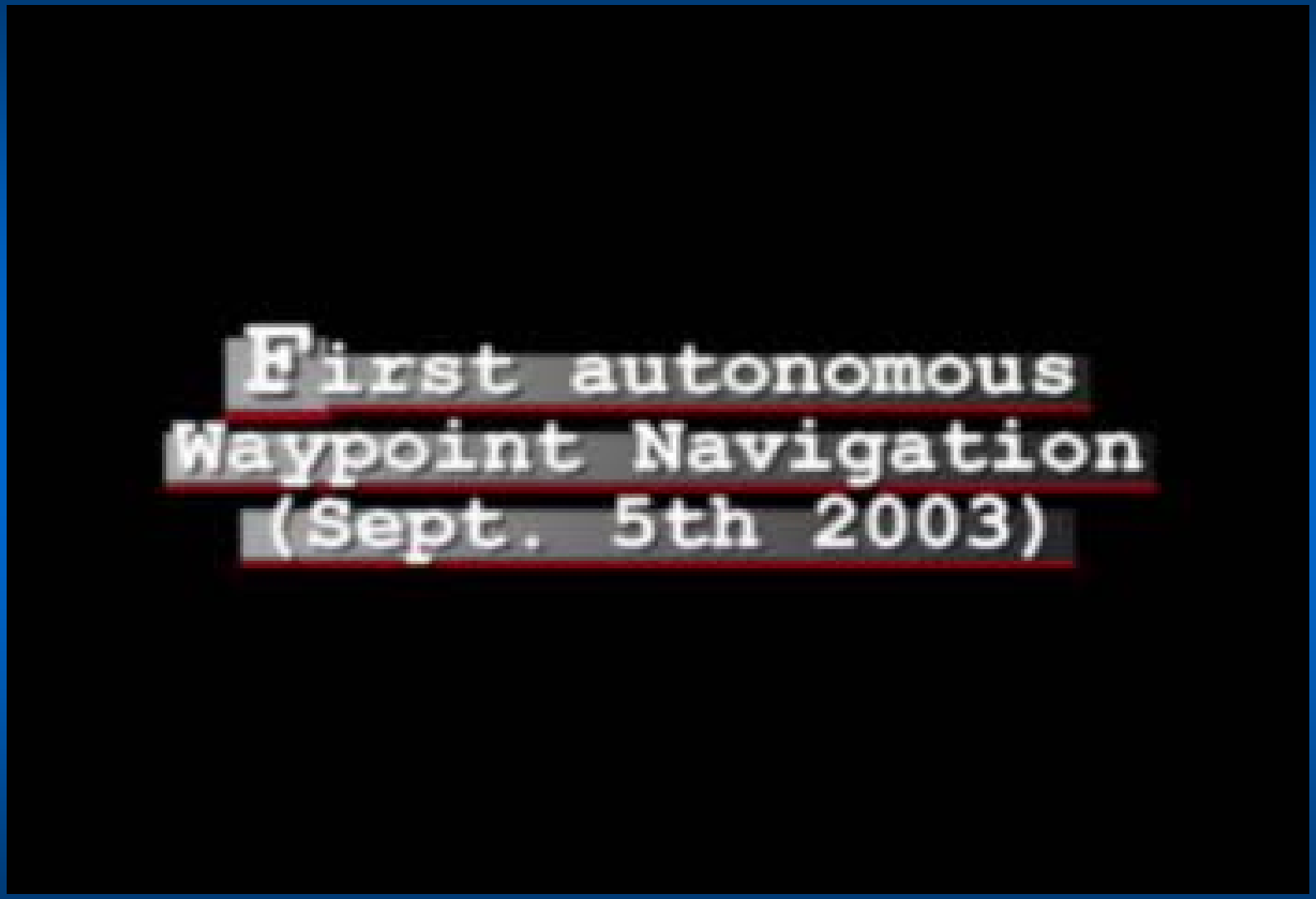


September 2003

Achieved with Carolo XXL and Carolo XL

CAROLO‘s Flight, Dec.20th 2002

First autonomous flight, Sept. 5th 2003



First European Micro Air Vehicle Conference and Flight Competition

EMAV 2004

Braunschweig, Germany

13 – 14 July 2004

German Institute of Navigation

-Deutsche Gesellschaft für Ortung und Navigation e.V.-